Experimental investigation of mechanical properties of Al6061 hybrid reinforced with mica powder and silicon carbide

[1]Chethan IC, [2]Praveen B,[3]Jeevith K P,[4]Prashant B,[5]Bharat
[1]Assistant Professor,[2]Research associate,[3]Research associate, [4]Research associate, [5]Research associate
[1]Department of Aeronautical Engineering,
Srinivas Institute of Technology, Mangalore,India

Abstract: In modern day's composite materials play a vital role in many industries and research field. Composites are extensively used in aircrafts for their best strength to weight ratio. They are anisotropic, i.e. can be designed for best strength in a particular direction. This work involves the development of metal matrix composite materials by combining the desirable attributes of metals and reinforcements. Here aluminium of 6061 issued as metal matrix composites with the Mica and Silicon Carbide as reinforced material. In stir casting Al 6061 is mixed with 0%, 2%, 4%, 6% of Silicon Carbide and 2% of mica to form composites. Composites materials possess improved mechanical properties e.g. lower density, good corrosion resistance, high hardness and wear resistance. Compression, Hardness and Tensile tests are performed to study the mechanical properties. From this work, it can be concluded that the composites compression strength will be increases with considerable weight reduction could be better substitute for use in the interiors of the aircraft.

***IndexTerms*– Hybrid Composite, stir casting, Al 6061, Silicon Carbide, Mica.**

I. INTRODUCTION

Composite material is a combination of two or more different substances. They are combined together to form a structure with properties that differ from the individual materials. The individual components remain distinct within the finished structure.The two constituents are reinforcement and a matrix. The advantages of composite materials are they have high strength to weight ratio, high stiffness and light weight, when compared with other materials, allowing for a weight reduction in the finished part. The reinforcing phase provides the strength and stiffness.

Metal matrix composites, at present though generating a wide interest in research fraternity, are not as widely in use as their plastic counterparts. High strength, fracture toughness and stiffness are offered by metal matrices than those offered by their polymer counterparts. They can withstand elevated temperature in corrosive environment than polymer composite. Most metals and alloys could be used as matrices and they required reinforcement materials which need to be stable over a range of temperature and non-reactive too light metals from the matrix for temperature applications and the reinforcement in addition to the aforementioned regions and characterized by high moduli.

The mechanical properties of the composite at various temperatures determine the service temperature of composites. The most metals, ceramics and compounds can be used with matrices of low melting point alloys. The choice of reinforcement becomes more stunted with increase in the melting temperature of matrix materials.

Metal matrix composites (MMCs) usually consist of a low-density metal, such as aluminium or magnesium, reinforced with particulate or fibres of a ceramic material, such as silicon carbide or graphite. Compared with unreinforced metals, MMCs offer higher specific strength and stiffness, higher operating temperature, and greater wear resistance, as well as the opportunity to tailor these properties for a particular applications. However, MMCs also have some disadvantages compared with metals. Chief among these are the higher cost of fabrication for high-performance MMCs, and lower ductility and toughness. Presently, MMCs tend to cluster around two extreme types. One consists of very high performance composites reinforced with expensive continuous fibres and requiring expensive processing methods. The other consists of relatively low-cost and low-performance composites reinforced with relatively inexpensive particulate or fibres.

Al 6061 is a precipitation-hardened aluminium alloy, containing magnesium and silicon as its major alloying elements. Originally called "Alloy 61S", it was developed in 1935. [10] It has good mechanical properties, exhibits good weld ability and is very commonly extruded. [11] It is the one of the most common alloys of aluminium for general-purpose use.

Aluminium 6061 is more easily worked and remains resistant to corrosion even when the surface is abraded, a thin Al clad coating for corrosion resistance. [14]

The mechanical properties of Aluminium 6061 depend greatly on the temper or heat treatment of the material. [12]

II. OBJECTIVES

The overall purpose of the described in this report was to determine the role of metal-matrix composites particularly in aircraft application. The literature review reveals that most of researchers are concentrated either on machining or developments of Aluminium MMCs with respect to the mechanical properties. The present work has been done with the following objectives.

1. Fabrication of Al MMC sample by considering material properties.

2. Testing of Al MMC samples for mechanical properties and collection of experimental data.
3. Developing the new Al MMCs with selected optimal parameters combination.
4. Evaluation of new Al MMCs for mechanical properties choosing the best one which possess good mechanical properties.

III. METHODOLOGY

Methodology deals with the systematic representation of the method used in the research or an analysis. With reference to our project it encompasses the theoretical analysis of the methods, principles used, quantitative or qualitative techniques to fabricate and test the metal matrix composite. It also includes a consideration of concepts and theories which underlie these methods.

The whole methodology may be divided as fabrication of composite material followed by testing. While fabrication of composite material is done for various percentages of filler material via 0%, 2%, 4% and 6% testing is done to evaluate mechanical properties of composite.

Stir casting method was used for the fabrication of composite. Tensile test, compression test and hardness test were conducted to evaluate the mechanical properties as shown in Figure.3.1. All the test for tensile, compression are done by using the universal testing machine and hardness test is conducted using Brinell hardness test.

IV. FABRICATION

The materials used for fabrication of metal matrix composite are alloy, reinforcement. The material used here is Al6061 is tabulated. A Silicon carbide is used as a reinforcement and mica is used as a second reinforcement. Three different compositions, taking 2%, 4% and 6% of Silicon carbide and 2% mica as a constant required composites are fabricated. The details of these material are given in the Table 3.1. Table 3.2 give the composition of Al6061.

Table 1.1 Material used

Metal	Aluminium
1st reinforcement	Silicon carbide
2nd reinforcement	Mica

Table 1.2 Composition of Al6061 [6]

Cu	Si	Mg	Mg	Fe	Ti	Zn	Al
0.15-0.4	0.4-0.8	0.8-1.2	Max 0.15	Max 0.7	Max 0.15	Max 0.25	Balance

V. STIR CASTING

In stir casting we use stirrer to agitate the molten metal matrix. The stirrer is generally made up of a material which can withstand at a higher melting temperature than the matrix temperature. Generally stirrer is used in stir casting. The stirrer is consisting of mainly two components cylindrical rod and impeller. The one end of the rod is connected to impeller and other end is connected to shaft of motor the stirrer is generally held in vertical position is rotated by a motor at various speeds. The resultant molten metal is then poured in die for casting. Stir casting is suitable for manufacturing composites with up to 30% volume fractions of reinforcement.

1 Electrical motor: electrical motor is an electrical machine that converts electrical energy into mechanical energy. It is used in stir casting process for stirring the stirrer.

2 Stirrer screw: stirrer propeller shaft screw is used for holding the rotor with the electric motor and which make the rotor rotate when the electric motor is started.

3 Reinforcement: In behavioural psychology, reinforcement is a consequences that will strengthen an organism's further behaviour whenever the behaviour is preceded by a specific antecedent stimulus.

4 Furnace: furnace is a device used for high temperature heating. The furnace transfers heat to the living space of building through an intermediary distribution system.

5 Crucible: A crucible is a container that can withstand very high temperatures and is used for metal, glass and pigment production as well as a number of modern laboratory process.

6 Rotor: The rotor is the moving components of an electromagnetic system in the electric motor, electric generator or alternator. Its rotation is due to the interaction between the winding and magnetic fields which produces a torque around the rotor's axis.

VI. TENSILE TEST

Tensile strength is one of the important parameters which is used to determine the applications of a material.The ASTM standard that has been applied for tensile test is E8. The cylindrical rod casted by stir casting method is machined with respect to standard. A dumbbell shaped specimen was fixed at the ends of the universal testing machine. Tensile load was applied until the break point and the corresponding values were recorded.

VII. COMPRESSION TEST

Compression strength is the capacity of a material or structure to withstand loads tending to reduce size. In this compression test fixture was designed to be reusable, provide, accurate and reproducible data and to eliminate premature "brooming" failures. A compressive analysis between this test method and ASTM E9 for compressive properties of unidirectional composites. The compression strength is usually obtained experimental by means of compressive test. The apparatus use for this experiment is same as that used in a tensile test.

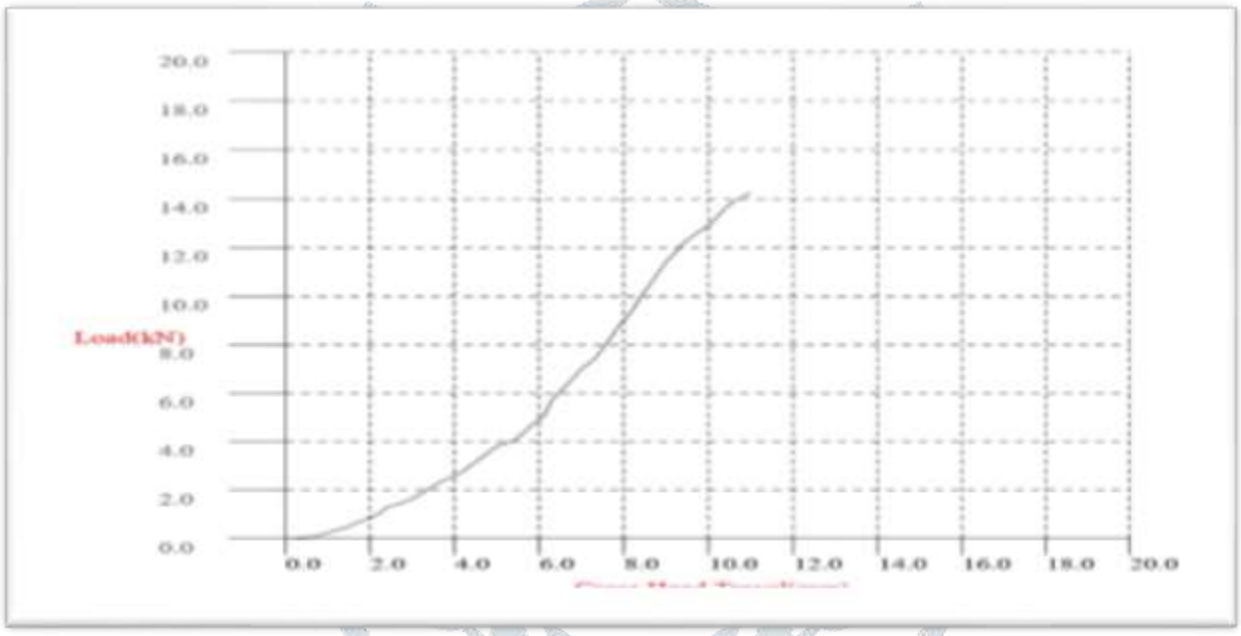
VIII. HARDNESS TEST

Brinell hardness test was carried out with a finely polished plate surface. The surface was placed below ball indenter and three sets of impression were made and on a average the Brinell Hardness Number (BHN) was obtained.

IX. RESULT

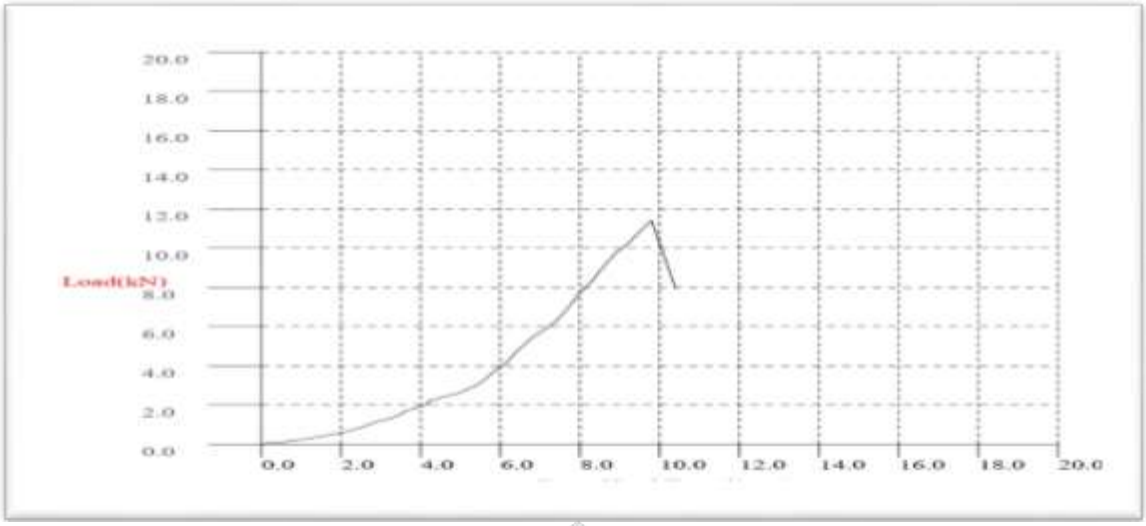
1. TENSILE RESULT:

The tensile test was conducted for the specimen of 100% Al6061 and the result were obtained as shown below:



Test Reference	ASTM E8-16a	Peak Load	19.88 kN
Initial Gauge Length (L0)	50mm	Max. C.H. Travel	17.5 mm
Final Gauge Length (L1)	52.21 mm	Tensile Strength	160.69 N/mm^2
Outer Diameter(Initial)	12.55 mm	Load at Yield	17.48 kN
Inner Diameter(Initial)	0 mm	C.H. Travel at Yield	14.7 mm
% Elongation	4.42 %	Yield Stress	141.29 N/mm^2
Test completed due to Specimen Break		Load at Break	19.88kN
		C.H. Travel at Break	17.50 mm

The tensile test was conducted for the specimen of Al6061 reinforced with 6% of SiC and 2% of Mica and the result were obtained as shown below:

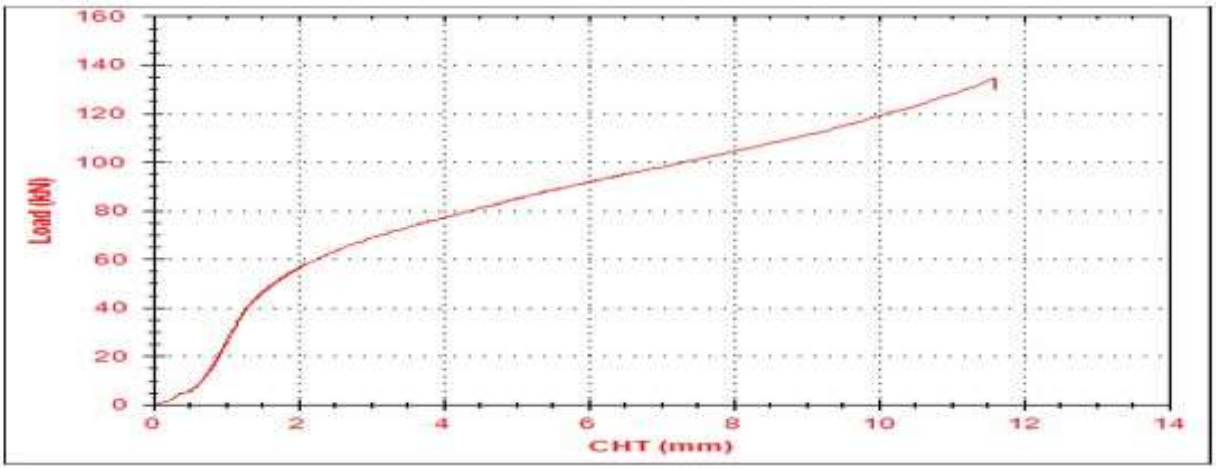


Test Reference	ASTM E8-16a	Peak Load	11.40 kN
Initial Gauge Length (L0)	50mm	Max. C.H. Travel	9.8 mm
Final Gauge Length (L1)	50.46 mm	Tensile Strength	114.92 N/mm^2
Outer Diameter(Initial)	12.5 mm	Load at Yield	10.64 kN
Inner Diameter(Initial)	0 mm	C.H. Travel at Yield	9.4 mm
% Elongation	0.92 %	Yield Stress	106.85 N/mm^2
Test terminated due to manual break		Load at Break	14.24 kN
		C.H. Travel at Break	11.00 mm

2. COMPRESSION RESULT:

The compression test was conducted for the specimen of 100% Al6061 and the result were obtained as shown below:

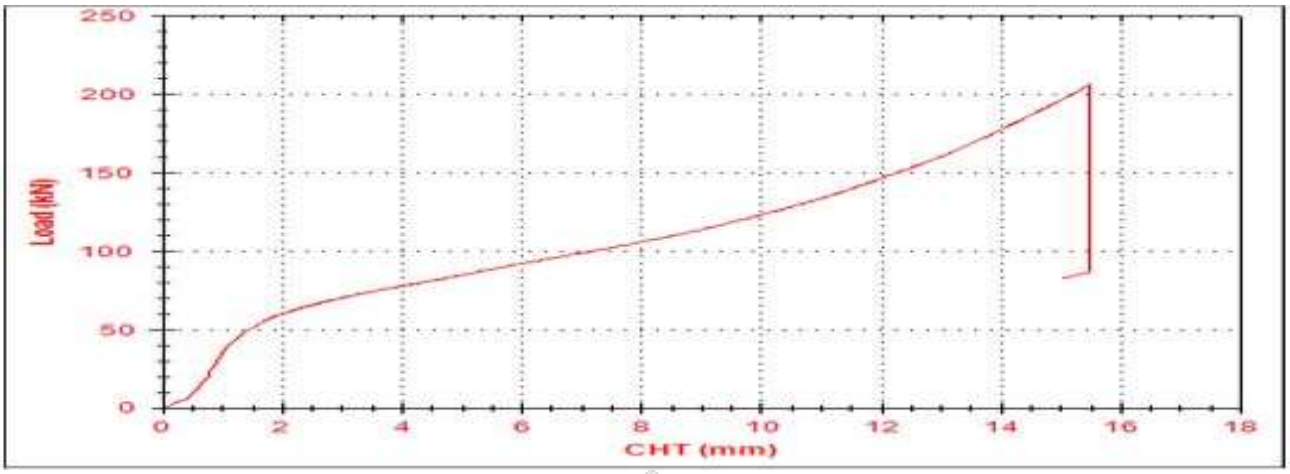
1. Load at Peak : 134.330 kN
2. C.H. Travel at Peak : 11.610 mm
3. Compression Strength : 427.586 N/mm^2



The compression test was conducted for the specimen Al6061 reinforced with 6% of SiC and 2% of Mica and result were obtained as shown below:

1. Load at Peak : 206.02 kN
2. C.H. Travel at Peak : 15.48 mm

3. Compression Strength : 655.783 N/mm^2



3. HARDNESS RESULT:

The hardness test was conducted for the specimen of 100% Al6061 and the result was obtained as shown below:

Specimen No.	Aluminium	Mica (%)	SiC (%)	Trail	BHN
1	6061	0	0	1	56.8
	6061	0	0	2	56.8
	6061	0	0	3	57.3
				Avg	57.0

The hardness test was conducted for the specimen Al6061 reinforced with 2% of SiC and 2% of Mica and the result was obtained as shown below:

Specimen No.	Aluminium	Mica (%)	SiC (%)	Trail	BHN
2	6061	2	2	1	59.5
	6061	2	2	2	59.5
	6061	2	2	3	59.0
				Avg	59.3

X. CONCLUSION

The present work is successful in carrying out the synthesis of Silicon Carbide/Mica reinforced with Aluminium matrix composites so the following conclusions have been made from various mechanical tests conducted.

- In Hardness test maximum resistance to indentation is displayed by the hybrid composite specimen with Al6061 SiC 2%, Mica 2% by weight as 59.3 BHN (Brinell Hardness Number) and minimum hardness is displayed by the specimen with Al6061 SiC 6%, Mica 2% by weight as 51.7 BHN.
- In compression test maximum compression strength observed in the specimen with Al6061 SiC 6%, Mica 2% is 655.783 N/mm^2 and minimum compression strength observed in the specimen with 100% Al6061 is 427.586 N/mm^2. Hence this shows that compression strength increases as the percentage of reinforcement increased by weight.

- In tensile test maximum tensile strength is observed for the specimen with 100% Al6061 and minimum tensile strength observed for the specimen with Al6061 reinforced with 6% SiC and Mica 2%. Hence the tensile strength is found to decrease with the increase in percentage of reinforcement by weight.

REFERENCES

1.“Mechanical properties in Aluminium Silicon Carbide Mica hybrid metal matrix composite” P. Saravanan, M. ShanmugaPriyan, R Raghuram
2. “Metal matrix composites offer the automotive Industry an opportunity to reduced vehicle weight, improve performance” Anthony Macke, B.F. Schultz, Pradeep Rohatgi
3. “Fabrication of metal matrix composite by stir casting method” Dinesh Pargunde, Prof. DhanrajTambuskar, Swapnil S. Kulkarni
4. Li-na GUAN Na, GENG Lin, ZHANG Hong-wei, HUANG Lu-jun effects of stirring parameters on tensile property. Trans. Nonferrous Met. Soc. China 21(2011) s274-s279.
5. Gowri Shankar M.C, Jayashree P.K, Raviraj Shetty, Sharma S.S review of effect SiC on stir cast Al MMC international journal of current engineering and technology 3 (3), 1061-1071, 2013
6. N.S. Kalyankar, R.D. Shelke, D.D. Barkul a reviewed on effect of properties of Al-SiC composite fabricated. Int. J. Res. Eng.Tchnol. 5 (2), 283-287, 2016
7. J. Jebeen Moses, I. Dinaharan, S. Joseph Sekharprocedia material science 5, 106-112, 2014
8. Jaswinder Singh, Amit Chauhan ceramic international 42 (1) 56-81, 2016
9. M.A.McEvoy and N.Correl, (2015) materials that couple sensing, actuation and communication, since 347(6228)
10. Robert E. Sanders, Jr. (2001). “Technology innovation in Aluminium products”.
11. “Aluminium alloys”. Materials management Inc. 23 December 2015.
12. Alcoa 6061 data sheet archived 2006-10-20 at the way back machine.
13. Aluminium information at aircraftspruce.com, accessed October 13, 2016
14. Aluminium 6061 archived 2013-01-25 at Archive.is. Homebuiltairplanes.com